

Low-Cost Turbomachinery Technology

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Typically, turbomachinery used in liquid rocket engines is composed of complex geometries made from high strength-to-weight super alloys. These high-performance machines usually have long design and fabrication cycle

times—on the order of 3 to 5 years. Such factors increase development time and result in high costs.

A simple, low-cost turbopump was designed in-house to demonstrate the ability to reduce the overall cost and life-cycle time of turbomachinery. The subject turbopump design, SIMPLEX, has been engineered to provide a discharge pressure of 1,500 pounds per square inch absolute of liquid oxygen at 90 pounds mass per second, as shown in figure 36. This size range

would be capable of supporting a 40,000-pound-thrust hybrid motor. The SIMPLEX turbopump will be powered by gaseous nitrogen or gaseous oxygen, eliminating the need for an interpropellant seal required to separate the fuel-rich turbine gases from liquid oxygen, and resulting in a simplified design. Materials used in the turbine flow paths will utilize existing characterized metals at 800 degrees Rankine that are compatible with a warm oxygen environment. The goal for this effort

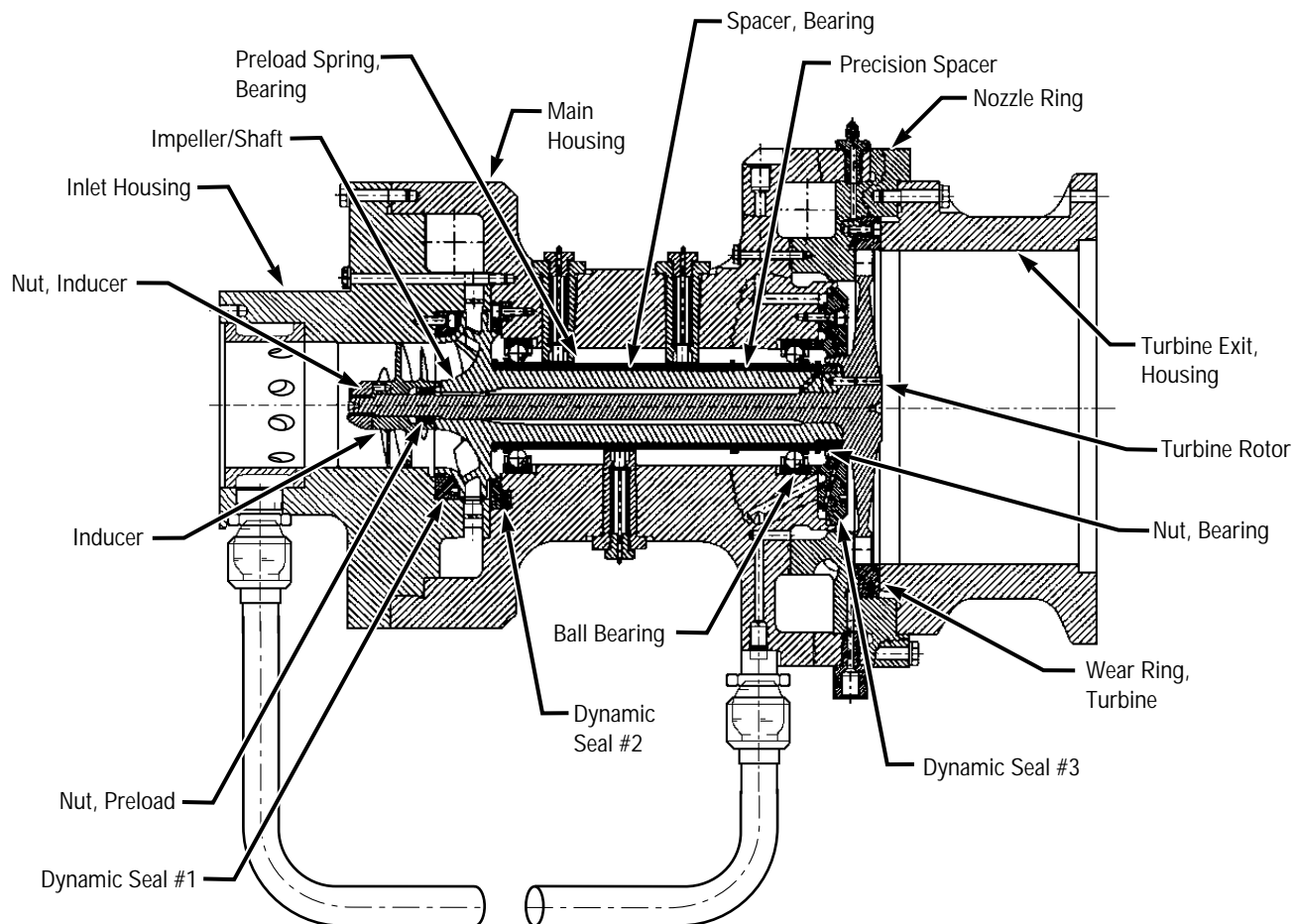


FIGURE 36.—SIMPLEX turbopump cross section.

was to reduce the design and fabrication cycle by a factor of 2.5 (18 months). The cost goal for the first unit fabrication and assembly was \$130,000, which represented a reduction factor of 10 when compared to similar turbopumps.

The design and analysis were completed in less than a year, and the detailed analysis process itself was completed by a multidisciplined, concurrent engineering team. Manpower, schedule, and cost data were tracked during the process for comparison to the initial goal. The SIMPLEX hardware has been assembled. Three test series are planned over the following 8 months. Overall design, fabrication, and assembly were completed in 27 months—a reduction in cycle time by a factor of 1.7. Actual unit cost of the first assembly hardware was \$205,000 (a reduction factor of 6). Total program cost was only \$315,000, as compared to \$500,000, the original cost goal (a savings of 37 percent). Although unit cost and schedule goals were not achieved, substantial improvements have been demonstrated. The SIMPLEX turbopump is currently in testing at MSFC.

The in-house design demonstrated the capability of developing a low-cost liquid-oxygen turbopump via an improved design and fabrication process. The prototype will also demonstrate a liquid-oxygen pump driven by an oxidizer-rich turbine gas. The increased ability to estimate rocket engine turbomachinery costs has been another benefit.

Marsh, M.; Cowan, P.; Forbes, J.; and Van Hooser, K. May 17–19, 1994. SIMPLEX Turbopump Design. Presented at the 1994 Conference on Advanced Earth-to-Orbit Propulsion Technology, MSFC.

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